MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

EEL1196 – INSTRUMENTATION AND MEASUREMENT TECHNIQUES

(All Sections/Groups)

5 JULY 2023
9.00 A.M. – 11.00 A.M.
(2 hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 6 pages including cover page with 4 questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) State the difference between the terms 'Sensitivity' and 'Resolution'. [4 marks]

(b) A piezoelectric sensor has the following input and output data shown in **Table Q1(b)**:

Table Q1(b)

Input force (N)	Output charge (nC)
1	2.5
3	5.0
5	7.5
7	10.0

Evaluate the sensitivity of the sensor. [3 marks]

(c) The current, I flowing through a resistance R is measured by Ohm's Law as follows, where V is the voltage drop.

$$I = \frac{V}{R}$$

It is given that $R = 100\Omega \pm 5\%, V = 12\text{V} \pm 2\%$.

(i) Determine the value of I. [2 marks]
(ii) Obtain the expression for the limiting error of I. [5 marks]
(iii) Hence, evaluate the limiting error of I in percentage form. [2 marks]

(d) According to Newton's law of universal gravitation, the magnitude of the attractive force (F) between two bodies is directly proportional to the product of their masses, m_1 and m_2, and inversely proportional to the square of the distance, r, between their centers. G is the gravitational constant.

$$F = \frac{Gm_1m_2}{r^2}$$

Determine the dimension and base unit of G.

[5 marks]

Continued...

(e) With the aid of relevant example(s), define parallax error. Discuss two techniques to overcome this type of error. [4 marks]

Question 2 (25 marks)

(a) Discuss the method of damping torque suitable for an attraction-type moving iron instrument. Justify your answer. [4 marks]

(b) The moving coil of a permanent magnet moving coil (PMMC) voltmeter has a length of 5cm and width of 2cm with 200 turns. The control spring exerts a torque of 6×10^{-4} Nm. The full-scale deflection is 30 divisions on the scale of the meter. The magnetic flux density in the air gap is $1Wb/m^2$, and the moving coil has a resistance of $1k\Omega$.

(i) Calculate the maximum voltage that can be measured by the voltmeter. [3 marks]

(ii) Estimate the resistance that must be put in series with the moving coil resistance to increase the maximum voltage measurement in part (b)(i) to 12V. [3 marks]

(iii) After the extension, determine the voltage reading which corresponds to a deflection of 10 divisions of the meter reading. [3 marks]

(c) State an advantage and a disadvantage of using a bar sample for magnetic tests. [2 marks]

(d) In a DC magnetic test, a ballistic galvanometer (BG) with a constant of $50\mu C$/div and 3Ω internal resistance is used to measure the magnetic permeability of a ring sample. The BG is connected to the ring sample with a 300 turns search coil and a resistance of 7Ω. The ring sample has a cross-sectional area of $2cm^2$ and a mean diameter of 8cm.

(i) Calculate the magnetic flux density in the ring sample, if the BG gives a throw of 8 divisions. [4 marks]

(ii) If the current supplied in the 200 turns of magnetizing coil is 3A, determine the magnetic permeability of the sample. [4 marks]

(e) Determine the BG constant if it gives a throw of 13 divisions when a Hilbert magnetic standard bar is pulled out of a 250-turn coil connected to it. The bar is known to have a flux of 0.6×10^{-3} weber and the resistance of the coil is 9Ω. The internal resistance of the BG is negligible. [2 marks]

Continued...

Question 3 (25 marks)

(a) A Wheatstone bridge shown in **Figure Q3(a)** is used to measure an unknown resistance, R_x. The values of the resistors are $R_1 = 5k\Omega$, and $R_3 = 2k\Omega$. Determine the range of R_x if the R_2 is adjustable from 1kΩ to 9kΩ. [3 marks]

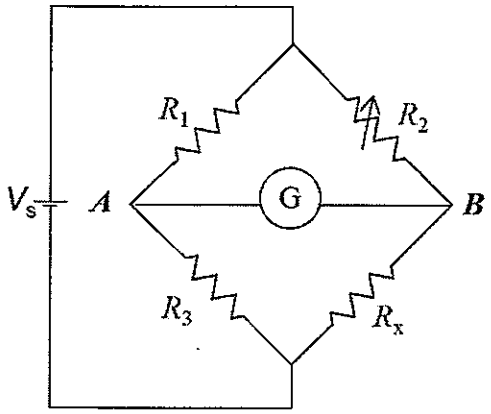

Figure Q3(a)

(b) A series resistance inductance bridge shown in **Figure Q3(b),** is connected to an AC source operating at 50Hz.

(i) Derive the equations for R_x and L_x. [8 marks]

(ii) If the bridge is balanced when $R_1 = 4.5k\Omega$, $R_2 = 8k\Omega$, $R_3 = 3k\Omega$, $R_4 = 870\Omega$, and $L_1 = 20mH$, find the values of R_x, L_x [4 marks]

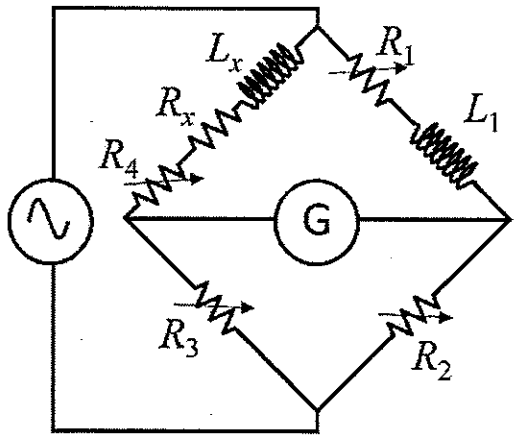

Figure Q3(b)

Continued...

(c) A parallel resistance capacitance bridge shown in **Figure Q3(c)**, is used to measure the unknown capacitance C_x with its internal resistance R_x. The bridge is balanced when the resistances $R_1 = 220k\Omega$, $R_2 = 15k\Omega$ and $R_3 = 23k\Omega$. The capacitance $C_1 = 0.6\mu F$. Derive the equations for C_x and R_x and find their respective values.

[10 marks]

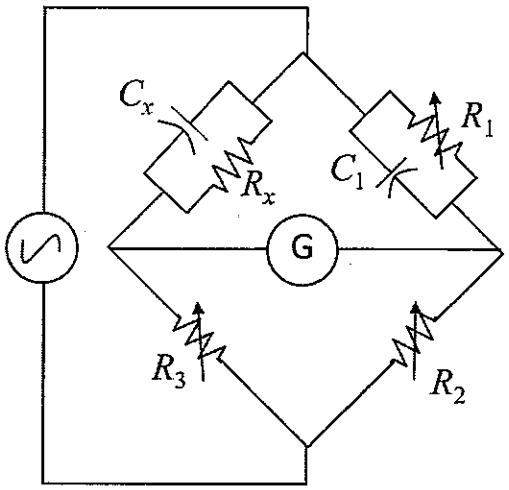

Figure Q3(c)

Question 4 (25 marks)

(a) A 60Hz, 415V three-phase power transmission line is connected to a balanced three-phase star-connected load impedance. If the load impedance per phase consists of 50Ω resistance and 100mH inductance, calculate:

(i) the power factor of the load impedance per phase. [3 marks]
(ii) the line current of the power lines. [3 marks]
(iii) the total power absorbed by the load. [3 marks]

(b) A 200V, 10A energy meter on full load with unity power factor makes 75 revolutions in 300 seconds. If the designed speed of the disc is 500 revolutions per kWh, find the percentage error of the energy meter reading. Assume a single-phase load. [3 marks]

(c) Using a suitable diagram, describe the working principle of a linear variable differential transformer (LVDT). [5 marks]

(d) Compare a linear variable differential transformer (LVDT) and a potentiometer in terms of their sensitivity and lifetime. [1 mark]

Continued...

(e) Strain measurement using a strain gauge is affected by the ambient temperature. Describe how a dummy gauge can be used to compensate for the temperature effect. [4 marks]

(f) The initial resistance of a strain gauge is 140Ω. When a tensile force is applied on it, the resistance is 157Ω. If the strain is 0.024, calculate the gauge factor of the strain gauge. [3 marks]

End of Paper.